8.0 DISCUSSION

8.1 SUMMARY

The present randomised study evaluated add-on effects of 12 weeks integrated yoga therapy on pulmonary, autonomic, physical and psychological parameters in coal miners with COPD as an adjunct to conventional care. Results of the present study indicated that yoga elicited a significant improvement in pulmonary measurements, autonomic functions, sleep quality and QOL where as statistically significant reduction in dyspnoea, fatigue, anxiety, depression and pain after the yoga intervention, leading to some plausibly concrete conclusions. Significant, firm and progressive improvement in the key objective variables; FVC, FEV1, FEV1/FVC, FEF, PEFR, BP, HR, RR, functional exercise capacity, and SpO2 in the yoga group but not in controls indicate yoga's effectiveness.

8.2 COMPARISION WITH OTHER STUDIES

8.2.1 Similarities

These results offer further support for preliminary findings that have shown beneficial effects of yoga intervention in improving pulmonary and autonomic functions; reducing physical and psychological distressful symptoms such as dyspnoea, fatigue, depression, anxiety, insomnia and pain. The encouraging effects of yoga in this study are consistent with conclusions of previous studies (Donesky-Cuenco et al., 2009; Fulambarker et al., 2012; Santana et al., 2013). A meta analysis of five RCTs involving 233 patients concluded that yoga training has a positive effect on improving lung function and exercise capacity. The aggregate results of these studies suggested that yoga training was associated with a significant improvement in FEV1 (WMD: 123.57 ml, 95% CI: 4.12-243, P = 0.04), FEV1% pred (WMD: 3.90%, 95%

CI: 2.27-5.54, $P < 0.00001$), and 6 MWD (WMD: 38.84 m, 95% CI: 15.52-62.16, $P = 0.001$) (Liu et al., 2014). Several studies have proven the efficacy of yoga in improving FVC, FEV1 and PEFR in various populations (Behera, 1998; Birkel & Edgren, 2000; Dinesh et al., 2015; Katiyar & Bihari, 2006; Shankarappa, Prashanth, Nachal, & Malhotra, 2012; Soni et al., 2012; Yadav, Singh, Singh, & Pai, 2015; Yadav & Das, 2001).

In this study 6MWD increased by 59.45 m in the yoga group and 16.41 m in controls, a clinically significant difference in participants' exercise performance, similar to a pilot study (improved 21.5 ± 7.0m for yoga, 8.3 ± 10.9m for usual care) after yoga training (Donesky-Cuenco et al., 2009). Another study on severe COPD, 54 meters (95% CI, 37–71 m) was identified as the minimum difference in a COPD patient to perceive improvements between one test and another as clinically significant (Redelmeier, Bayoumi, Goldstein, & Guyatt, 1997). Another study observed a mean increase of 50 m (20%) in 6MWD for COPD patients after exercise and diaphragmatic strength training (Mahler, Fierro-Carrion, Mejia-Alfaro, Ward, & Baird, 2005; Weiner, Magadle, Berar-Yanay, Davidovich, & Weiner, 2000) showed comparable small decrease in dyspnoea intensity, regardless of improved exercise capacity after six weeks exercise training in COPD patients. Earlier study has reported yoga breathing exercise induced greater resting SpO_2 in patients with COPD (Pomidori, Campigotto, Amatya, Bernardi, & Cogo, 2009). Our results suggested that IAYT practice reduces self-reported depression and anxiety levels after 12 weeks of practice. The results are consistent with previously reported interventions based on yoga, which demonstrated positive beneficial effects on psychological and psychosocial factors in diverse conditions such as diabetes (McDermott et al., 2014), cancer (Rao et al., 2015), CAD (Raghuram et al., 2014), Low Back pain (Tekur et al., 2012) Osteoarthritis of knee (Ebnezar et al., 2014), pregnancy (Newham, Wittkowski, Hurley, Aplin, & Westwood, 2014; Maharana et al., 2013). Another study showed that yogic breathing (*Pranayama*) mitigates post traumatic stress disorder (PTSD) and depression (Descilo et al., 2010). A study by De Godoy & De Godoy (2003) reported reductions in depression and anxiety only among patients who participated in education and stress management in addition to exercise training during a 12-week intervention. Present findings of improved pain following yoga reflect reported significant improvements in a range of subjective factors, including overall sleep quality; sleep efficiency; sleep latency and duration; self-assessed sleep quality after 12 weeks of meditative yoga (Halpern et al., 2014). A recent study on 120 nurses who practiced yoga more than two times every week for 50-60 minutes has shown regular yoga improved sleep quality and reduced work stress after six months (Fang & Li, 2015). It is in agreement with preceding related studies which have shown improvement in sleep quality in varied populations (Chen et al., 2009; Cohen, Warneke, Fouladi, Rodriguez, & Chaoul-Reich, 2004; Garland et al., 2014; Hariprasad et al., 2013; Vitiello, Rybarczyk, Von Korff, & Stepanski, 2009). Our study also confirmed previous findings of reduction in pain following yoga program (Ebnezar et al., 2014; Haldavnekar, Tekur, Nagarathna, & Nagendra, 2014; Mustian, Sprod, Janelsins, Peppone, & Mohile, 2012; Tekur, Nagarathna, Chametcha, Hankey, & Nagendra, 2012b) and mindfulness-based stress reduction as a mind-body therapy including body scan, sitting and walking meditation (Banth & Ardebil, 2015).

8.2.2 Differences

Differences in the sampling, study design, characteristics of participants, type of yoga training, and duration of yoga may account for differences in findings to some extent. Our population comprised mild to severe COPD sufferers attending an outpatient clinic. Our findings may differ from those of hospital-based studies. To meet exacting demands of methodology, some recent studies may have overlooked basic features of yoga, which is much more than breathing exercises. Including all components of yoga together as in IAYT used in this study has more beneficial effects. However, none of the previous trials have gone into the possible mechanisms by which yoga might help COPD and did not provide adequate data or sufficient clinical evidence to support the beneficial effects of yoga training on these relevant findings.

Few studies have shown non-significant change in FVC, FEV1, PEFR after 7 days of yoga (Khanam, Sachdeva, Guleria, & Deepak, 1996), decline in FEV1 after pulmonary rehabilitation (Foglio et al., 2007). Improvements in lung function, however, were not consistent and were subject to the length of yoga training, the type of yoga practice used (e.g., breathing exercises and yoga postures), and the type of participants followed over time. A study reported that changes in depression and state and trait anxiety did not significantly differ between the two interventions (6 weeks of weekly yoga classes together with exercise, compared to a 6 weeks weekly group exercise) (GDS15, $P = .749$, STAI-S, $P = .595$, STAI-T, $P = .407$ (Chan, Immink, & Hillier, 2012). Another study has similarly obtained unclear effects following yoga intervention (Kirkwood, Rampes, Tuffrey, Richardson, & Pilkington, 2005).

8.3 MECHANISM

Mechanisms to account for the favourable effects of yoga training are complex and yet to be elucidated. Several factors may contribute to the beneficial effects observed in this study. In our study, a greater improvement of the pulmonary parameters was observed. This may be because our participants practiced for a longer duration (12 weeks) and the intervention given was integrated yoga which is a combination of asana, pranayama, breathing and loosening practices, relaxation, meditation interspersed with relaxation. Yoga represents a form of mind-body fitness. IAYT includes a combination of *asana*s, *pranayama*, meditation and relaxation, and internally directed mental focus on awareness of the self, breathing and energy. Regular practice tones up general body systems, calms the mind, improves blood circulation, enhances energy levels, expands the lungs, relaxes chest muscles, and increases strength of respiratory muscles (Nagarathna & Nagendra, 2013). It has been found that slow comfortable breaths help patients breathe more deeply by efficient of shoulder, thoracic, and abdominal muscles, lead to an increase in parasympathetic modulation and regulating chemoreceptive sensitivity (Bernardi et al., 2001). Consciously controlled breathing practices influence and establish harmony between the sympathetic and the parasympathetic nervous system (Jain, Srivastava, & Singhal, 2005). Observed improvements in perception of dyspnoea may result from decrease in sympathetic reactivity achieved by *yogic* training, promoting broncho-dilatation by correcting abnormal breathing patterns and reducing muscle tension in inspiratory and expiratory muscles (Nagarathna & Nagendra, 2008). Improved breathing patterns, may widen bronchioles so that larger numbers of alveoli can be efficiently perfused (Soni et al., 2012). *Pranayama* practices stretch lung tissue, alleviating dyspnoea by decreasing dynamic hyperinflation of the rib cage and recuperating gas exchange, enhancing respiratory muscles' strength and endurance, and optimizing thoraco-abdominal patterns of motion (Gosselink, 2003). Modifications in efferent vagal activity affect the caliber of airways reducing dyspnoea.

Observed improvements in fatigue scores can be explained by various interrelated factors. First, in *asana*s, muscles are toned, energy conserved and sympathetic activity balanced, while mental relaxation and greater parasympathetic function affect cardio respiratory activity, relax the vasomotor centre, and reduce pulse rate, ultimately leading to reduced feelings of fatigue. *Pranayama* helps in full utilization of the lungs, enhancing ventilatory function, reducing oxygen debt, improving gas exchange and thus preventing exhaustion.

Observed improvements in 6MWD are due to yoga's beneficial effects on musculoskeletal and cardio-respiratory systems, improving cardiovascular efficiency and homeostatic control of the body. Muscle conditioning during yoga's intense stretching postures help by improving oxidative capacity and strength of skeletal muscles, flexibility, endurance, coordination, power, static and dynamic stability, decreasing glycogen utilization, in turn improving physical performance and increasing walking pace and stride length (Katiyar & Bihari, 2006). Yoga relaxation techniques have shown to improve cardiopulmonary endurance through body-and-breath control, which manifest clinically as improved lung capacity, increased oxygen delivery and decreased pulse rate, resulting in overall improved exercise capacity. Improvements in 6MWD in control group were statistically but not clinically significant (<54m). Changes in score may also be due to ordinary performance (no intervention), improved coordination, finding optimal stride length, or overcoming anxiety (Crapo et al., 2002).

Improvements in blood oxygen saturation may be associated with practice of *pranayama*, which engage normally unventilated lungs and help circulation, ventilation and perfusion better, increasing oxygen delivery to muscles. *Pranayama* increase strength of respiratory muscles, reduce sympathetic reactivity, probably through improved oxygen delivery to tissues, possibly supplemented by acquired "tolerance" to hypoxia produced by changes in chemo-reflex threshold and decreased dyspnoea.

Deep relaxation technique (DRT), an important component of IAYT showed significant reductions in the yoga group's PR, possibly due to modulation of cardiac autonomic function and cardio-respiratory efficiency. It may also synchronize neural elements in the brain, leading to ANS changes, resulting parasympathetic dominance and blunted sympathetic activity leading to reduced PR (Jerath, Edry, Barnes, & Jerath, 2006). *Pranayama* modifies various inflatory and deflatory lung reflexes and interacts with central neural elements to improve homeostatic control (Tandon, 2012). In this study, yoga may have reduced ventilator requirements at the end of 6MWT, thereby decreasing PR.

The pathophysiology of depression and anxiety among COPD patient is complex and poorly understood. The physical, emotional and social impact of COPD may cause a self perpetuating cycle that has a severe impact upon a patient's physical and mental health status (Pumar et al., 2014). It has been shown that high scores on perceived stress and anxiety are related to increase in HPA axis activity (van Eck, Berkhof, Nicolson, & Sulon, 1996). The effects of yoga in our results can be explained by reduction in levels of psychophysiological arousal via triggering neuro-hormonal mechanisms that suppress sympathetic activity (Ray et al., 2001; Vempati & Telles, 2002), balance in the autonomic nervous system responses (Telles, Nagarathna, Nagendra, & Desiraju, 1993), alterations in neuroendocrine arousal (Harte, Eifert, & Smith, 1995; West, Otte, Geher, Johnson, & Mohr, 2004) through better regulation of the HPA axis (Pascoe & Bauer, 2015) resulting in reductions in stress and anxiety (Hoge et al., 2013). Better psychological health resulting from stress reduction might be due to relaxation techniques (Manzoni, Pagnini, Castelnuovo, & Molinari, 2008) which contribute to the observed improvements in CAT scores in our study. Thus, these psychological changes may explain the physiological changes observed as better outcomes seen in previous studies on integrated yoga in asthma (Nagarathna & Nagendra, 1985). Yoga unites body, mind and spirit; and enhances attention by calming down the restless mind (Nagarathna & Nagendra, 2013). Thus the deep physiological rest that is achieved by the components of *pranayama*, meditation and other mindfulness practices incorporated in the integrated yoga program could be the major factors explaining observed benefits. Overall, antidepressant effects of yoga programs can be attributed to stress reduction (Deberry, Davis, & Reinhard, 1989). Another study concluded the practice of meditation strengthens the mental resolve and hence decreases anxiety (Telles, Nagarathna, & Nagendra, 1998). Yoga practices decrease PNS and GABAergic activity that underlies stress-related disorders which results in amelioration of disease symptoms (Streeter, Gerbarg, Saper, Ciraulo, & Brown, 2012). Reductions in psychological hyper-reactivity and emotional instability achieved by yoga may be due to reduced efferent vagal reactivity (Raghuraj, Ramakrishnan, Nagendra, & Telles, 1998) already recognized as a main psychosomatic factor in asthma (Nagendra & Nagarathna, 1986) might have similar physiology in COPD also.

The relaxing *asanas* and *pranayama* harmonize the physiological system and initiate a relaxation response in the neuro-endocrinal system by which sleep gets deeper and sustained and can help to deal with pain (Vallath, 2010). The improvement in sleep quality in coal miners in this study might be due to relaxation technique, *pranayama*, and guided meditation, important component of our intervention through enhancement in foster states of relaxation, counteract intrusive thoughts, and decrease body tension increasing awareness in movement to relax tense muscles and to relieve mental stress (Anderson, Hurley, Staud, & Robinson, 2015). It is clearly in line with behaviours linked to improved sleep, stress reduction (Oken, Chamine, & Wakeland, 2015), muscle relaxation due to breathing exercises (Chien, Chung, Yeh, & Lee, 2015);(Sendhilkumar, Gupta, Nagarathna, & Taly, 2013; Vitiello et al., 2009). This has been demonstrated in a previous study which had reported improved sleep latency, sleep duration and significant decrease in the time taken to fall asleep (Manjunath & Telles, 2005).

Stress and pain are intimately related. Stress reducing effect of yoga seems to be a major mechanism of its efficacy in pain management in patients with COPD. Dyspnea is a distressing symptom of COPD associated with pain and CBT is known to relieve dyspnea by cardiac vagal modulation, dynamic hyperinflation, promoting arterial oxygen saturation, myelinated vagus nerve activity, and neuroplasticity (Norweg & Collins, 2013) with stabilizing effect on bronchial reactivity and reduced efferent vagal reactivity (Nagarathna & Nagendra, 1985). Yogasanas reduce muscle spasm and pain through deep local rest and repose that follow safe stretches done with awareness where as breathing exercises, relaxation, and meditation, these three aspects of yoga act to distract the mind from pain. During meditation several subtle level notional corrections may happen making it difficult to pay attention to the pain at the same time. Meditation attenuate the medial system of pain perception including brain regions in insula, as well as the lateral system in the thalamus (Nakata, Sakamoto, & Kakigi, 2014). This appears to cause an uncoupling of the sensory dimension of the pain experience from the affectively evaluative alarm reaction and reduce the experience of suffering via cognitive reappraisal (Kabat-Zinn, 1982) through controlled overtones of hypothalamo-pituitary-adrenal axis during chronic pain (Zheng, Hong, Hayes, & Wiley, 2015).